needed for use as food. Not less interesting, however, would be instances of the use of organic refuse derived from other sources. Can it be possible that the agricultural Indians of America, such, for instance, as the Moquis, have never thought of making this very obvious application of their domestic animals? When did the Aryan races take their first steps in provident agriculture? These questions must be extremely important to those who are studying the development of culture and civilization.

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A SKETCH OF COMPARATIVE EMBRYOLOGY.

BY CHARLES SEDGWICK MINOT.

IV.—THE EMBRYOLOGY OF SPONGES.

DURING the past six years our knowledge of the structure and development of sponges has made sudden and very great progress, perhaps greater than has occurred in any other department of zoölogy during the same period. The advance was introduced by the publication, in 1872, of Haeckel's monograph of the calcareous sponges. That work has been followed, in Germany, England, France and Russia, by numerous memoirs, among which the series of articles by Franz Eilhard Schulze stand first by their accuracy, their clearness, the beauty of the illustrations and the good temper (sometimes wanting in German scientific publications) of the criticisms on other investigators, but above all, by the value of the discoveries they announce. I think no zoölogist can read Schulze's papers without enjoying their rare combination of merits.

One of the results of these numerous recent researches has been to show that Haeckel's work is inaccurate to a startling extent. He figures in detail things he cannot have seen, because they do not exist, and he describes phenomena that do not occur. His fault is to make very positive statements and give very diagrammatic figures after a hasty examination, consequently his writings contain so numerous errors, sometimes about fundamental points, that even a positive statement of his, until confirmed by other investigators, has no authoritative value. This defect is most seriously to be deplored, for Haeckel is unquestionably one of the most daring and original thinkers of the modern speculative school, and many of his quickly made generalizations have

proved extremely fruitful, as others have been useless or misleading. Therefore, in spite of Haeckel's great and unusual endowments, which every one must recognize and admire, it is unsafe to quote his writings as authorities in matters of fact.[1] Having given my own opinion, I may add that while many of the younger naturalists bestow an almost unqualified admiration on Haeckel, several distinguished zoölogists severely condemn him as unscientific.

In order to understand the embryology of sponges, it is necessary to consider briefly their structure. The sponges of commerce are merely the skeletons of the living animals, the soft portions having been removed by maceration. During life the fibres, which make up the skeleton, are all covered by cells. The mass of the sponge is permeated by intercommunicating canals, connected with the exterior by numerous openings upon the surface, these openings are of two kinds, smaller ones called *pores*, by which currents of water enter the canals or tubes, and larger ones, or in some cases a single orifice, the *osculum*, through which the water passes out. The entire surface of the canals is lined by a continuous layer of cells, the *entoderm*. Over definite areas of this lining the cells are cylindrical, have a so-called collar, and are provided, each, with a single long sweeping cilium, or *flagellum (geissel)*, while over the intervening parts, the lining is composed of simple flat polygonal cells. In a few sponges *(Ascones)* the whole canal system is carpeted by flagellate cells. The flagella maintain the currents of water, sweeping in the particles of food, which are seized by the sponge as the water runs through. The external surface is entirely covered by a continuous stratum of flat polygonal cells, the ectoderm, between which and the canals lies the thick middle layer or mesoderm, in which the skeleton and the sexual products are developed.

The mesoderm is composed of numerous independent cells, each separated from its neighbors by amorphous intercellular substance, the specific character of which varies from species to species. Its consistency may be so slight that the cells can crawl about through it, like Amœbas. A certain portion of these cells are transformed into the genoblasts; usually either only eggs or only spermatozoa are produced in a single individual, but of those sponges, whose sexuality is known, a few are hermaphrodite.

[1] In Huxley's Anatomy of Invertebrates, the chapter on sponges is based on Haeckel's work and contains several important errors.

The various kinds of sponges are distinguished principally by their external shape, and the peculiarities of their skeleton and canal system. The form from which all sponges may be deduced is the Olynthus type, which has the following characteristics: 1, it is attached by its base; 2, there is a large vertical central cavity, which, 3, communicates with the exterior at the upper end, through the osculum, and 4, at the sides through the secondary canals and pores. Modifications, besides those before mentioned, occur in the relative size of the main cavity, and by the formation of additional oscula.

The principal kinds of sponges may be tabulated as follows:

A. Without any skeleton..........................Myxospongiæ.
B. With horny fibers (bathing sponges)...... ....Spongidæ.
C. With siliceous spicules (several distinct families)..siliceous sponges.
D. With calcareous skeleton...... ....Calcispongiæ.

The *Physemaria*, which Haeckel described as multicellular organisms, representing a permanent adult sponge-like gastrula condition, have excited the greatest interest among zoölogists. Recent investigations,[1] however, render it probable that Haeckel's description is entirely erroneous, and that these animals are really multinucleolate Rhizopods.

The *gemmulæ*, or winter buds, are not organs of sexual reproduction, but rather of regeneration. The tissues hibernate in a simplified condition, forming germ masses, the so-called buds; in the spring the sponge is regenerated by the renewal of its histological differentiation.

The formation of the egg presents no features requiring special comment from us. No polar globules have been discovered. Since the eggs and spermatozoa are ripe at the same time, the ova probably require to be fertilized, but I think no stage of the act of impregnation has yet been observed. The egg early becomes enclosed in a special capsule or follicle, developed by the neighboring cells of the mesoderm disposing themselves in a continuous layer around it. Within this follicle segmentation and the development of the embryo take place. It is a singularity of sponges, without a parallel among other animals, that the egg becomes the embryo without quitting its seat of formation—the follicle in which it grows up.

The sponge larva escapes from the body of the parent by

[1] E. Ray Lankester, Quart. Journ. Micros. Sci. 1879.

bursting the walls of the follicle, passing into the canal system, and escaping through one of the pores. At the time of its birth, the larval sponge has very distinctive peculiarities, and differs strikingly from all other larvæ.

The larva, when hatched, is egg-shaped (Fig. 16), the larger end is composed of large cells with granular contents, which hide the nuclei, while the pointed end consists of small cells, each of which bears a long vibratile hair, or flagellum. It is by these that the larva swims. During segmentation, however, the cells are all more or less alike, and the differentiation takes place in some species earlier, in others later, so that in some sponges *(Halisarca)*, there is even a stage in which the whole surface of the larva consists of small cells, and later, those cells around the large pole of the egg grow bigger and granular. Again, in some forms (e. g. *Chalinula)* the difference between the two sets of cells is much less, and the small cells cover a proportionately much larger area than in the embryo figured (Fig. 16).

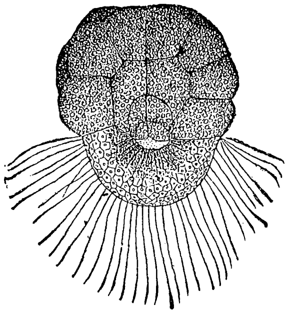

FIG. 16.—Egg-shaped larva, youngest free-swimming stage. *Sycandra raphanus*, after F. E. Schulze. About 530 diam.

There are also cells in the interior of the embryo, leaving, however, in certain cases a central cavity. Schulze states that in *Sycandra* there are no central cells, but Metschnikoff describes and figures them. These central cells are regarded by several authors as the primitive mesoderm.

The metamorphosis of the larva into the sponge has been observed in but very few species. The change takes place according to two distinct types, which cannot at present be brought into relation with one another, because in the first *(Sycandra)*, the large cells form the ectoderm, and the small cells the entoderm, while in the second *(Chalinula* and *Halisarca)*, the destiny of the two sets is exactly reversed, the small ciliated cells remaining external, the large cells becoming internal. In the latter case the embryo attaches itself by its broad end to a solid body, the small cells grow over the whole of the exposed surface; a branching cavity is formed in the interior, and pores and an osculum break through. There cannot be said to be any gastrula stage at all, nor does the osculum answer to an opening formed

by invagination. The skeleton begins to appear about the time the larva fixes itself.

In the other type of development, which has been observed in the higher calcareous sponges, there is both a temporary *pseudo-gastrula*, and a permanent gastrula differently formed, which is directly metamorphosed into the permanent sponge. The pseudo-gastrula normally occurs only before the larva leaves the follicle of the parent body, and arises by the turning in of the large cells, just as the finger of a glove may be inverted; the larva then appears like a cup formed of two membranes, the outer of small cells, the inner of large. Before long, however, the large cells are everted, and the embryo (Fig. 16) reassumes the characteristic egg-shape, and soon leaves the parent, swims about freely for two or three days, and finally permanently attaches itself.

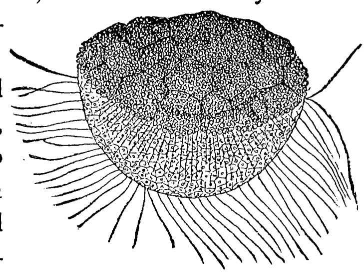

FIG. 17.—Older stage of Fig. 16.

While still free, it broadens, and its long axis shortens (Fig. 17), whereby the large cells begin to grow over the small ones, which are gradually pushed in more and more until they are fairly invaginated. The large cells advance further, gradually constricting the opening until it becomes quite small. Viewed from the oral side, at this stage, the embryo presents the appearance indicated by the outline, Fig. 18, *A*.[1] At this stage the larva fixes itself by its oral end. The cells around

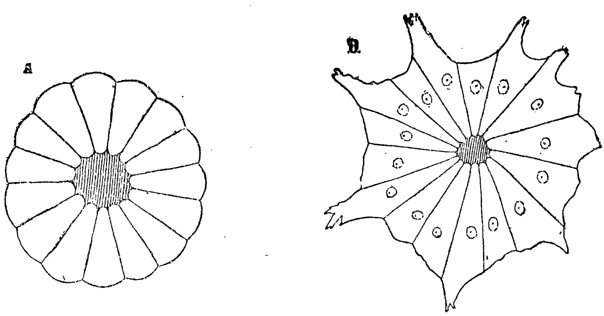

FIG. 18.—*A*. Oldest free-swimming stage, view of oral surface. *B*. The same after attachment. Larva of Sycandra, after F. E. Schulze, magnified about 240 diam.

the mouth nestle against the underlying surface, and send out

[1] In nature the upper and inner parts show through, rendering the outlines much less distinct.

from their external edges hyaline amœboid processes, which probably help the larva to hold on (Fig. 18, *B*). The central ends of the cells approach one another, meet and close the mouth. Fig. 19 presents a side view of a larva in this stage, and shows the inner cavity *c*, now closed; its lining of small cells *b*, and the exterior layer of granular cells *a*, the arrangement of which is particularly obscure, but they ultimately make the ectoderm and mesoderm.

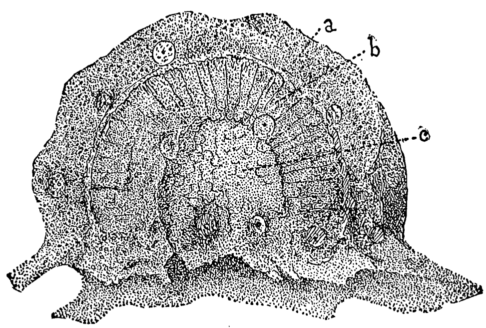

FIG. 19.—Vertical optical section of the attached larva of *Sycandra raphanus*. After F. E. Schulze, magnified about 500 diam.

The development now proceeds by the vertical elongation of the sponge to a cylindrical shape; the formation of a large secondary opening, the osculum at the upper end, and of small openings, *pores*, around the sides, leading into secondary tubes, which communicate with the large central cavity; finally the development of the skeletal spicules and of the mesodermic intercellular substance. The first spicules that appear are simple rods tapering towards both ends, and slightly curved. They lie nearly parallel to the external surface, scattered irregularly. Three and four rayed spicules also soon appear, and the whole skeleton grows rapidly. The sponge is now in the Olynthus stage.

The above account, though necessarily brief, shows that our present knowledge does not render the morphology of sponges explicable, because, although we should certainly consider, if we knew the larvæ alone, the small flagellate cells to be strictly homologous in all the embryos, yet in one case these cells form the internal digestive cavity, in another the external skin. At present the meaning of this divergence is unknown.

The systematic position of the sponges has been much discussed. At one time they were considered protozoic colonies, which they certainly are not. German zoölogists usually connect them with the Cœlenterata, but inasmuch as the development is not in the least cœlenterate, and the structure of the adult sponge

is in nearly every respect peculiar, it seems to me best to accept Prof. Hyatt's view, and place sponges by themselves as a distinct sub-kingdom of animals, the *Porifera*.

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   V. Die metamorphose von Sycandra raphanus, XXXI, p. 262.
   VI. Spongelia, XXXII, p. 117.
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   VIII. Hircinia und Oligoceras, n. g., XXXIII, p. 1.

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LIST OF THE BIRDS OF THE WILLAMETTE VALLEY, OREGON.

BY O. B. JOHNSON.

THIS is not meant to be a complete list of the avifauna of the region named, but only such a part as has fallen under my personal observation during a residence of over ten years at three different points, viz: Five years at East Portland, which is but six miles from the Columbia river; two years at Forest Grove, twenty-five miles west of Portland and at the foot of the Coast